

Carried with the wind: mass occurrence of *Zeiraphera griseana* (Hübner, 1799) (Lepidoptera, Tortricidae) on Vize Island (Russian High Arctic)

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Abstract. Vize Island, located in the northern part of the Kara Sea (79°30'N, 76°59'E), is one of the least studied islands of the Russian High Arctic in terms of its biota. Hundreds of live and freshly dead individuals of Larch Budmoth *Zeiraphera griseana* (Hübner, 1799) were observed on this island from 16 July–2 August 2020. This is the first and the only terrestrial invertebrate ever discovered on Vize Island. The moths were likely transported to the island by air currents from the northern part of the Krasnoyarsk region, where an outbreak of *Z. griseana* was reported on over 75,000 ha. The distance travelled by moths approached 1200 km. Thus, the high Arctic islands are less isolated from insect migrants than was commonly thought. These islands will be colonised by boreal insects as soon as changing environmental conditions allow the establishment of local populations.

Introduction

Arctic habitats have fascinated biologists for centuries. Nevertheless, their species-poor insect faunas provide little reward for entomologists to justify spending several weeks or even months in the hostile environments of tundra or polar deserts. Consequently, the data on insects from the high Arctic islands, excepting the Svalbard Archipelago, are based only on occasional collecting and therefore remain scarce. This is particularly true for moths and butterflies: ten Lepidoptera species (three residents and seven migrants) were discovered in Svalbard (Coulson et al. 2014), eight species are known from the Northern Island of Novaya Zemlya (Kullberg et al. 2019), no species were reported from Franz Josef Land (Coulson et al. 2014) and four species (two residents and two migrants) were collected on Bolshevik Island in the Severnaya Zemlya Archipelago (Makarova et al. 2013).

This scarcity of data prompts entomologists to appreciate any observation on insects made in the high Arctic and to carefully collect information on occasional migrants (e.g. Kaisila 1973; Lokki et al. 1978). The current climatic changes have given additional weight to studies of insect migration to high latitudes, because the rapid warming of the Arctic (Walsh 2014) increases the susceptibility of species-poor polar faunas to invasion by more southerly species—provided the insects can reach the high Arctic islands and survive there (Coulson et al. 2002). In this paper, we report a mass occurrence of Larch Budmoth *Zeiraphera griseana* (Hübner, 1799) on Vize Island.

Methods

Vize Island (discovered in 1932) is located in the northern part of the Kara Sea (79°30'N, 76°59'E), 575 km from the mainland and 275 km from the Severnaya Zemlya Archipelago (Fig. 1). This small (288 km²) ice-free and hilly lowland island (the highest elevation is 22 m above sea level) has many rivers and streams (Figs 2, 3). The mean air temperatures are positive only in July and August (0.5 °C and 0.1 °C, respectively). The uniform landscapes are dominated by forb and cryptogam high-Arctic tundra (classification follows Walker *et al.* 2005). Vascular plants and lichens cover 5–10% and 10–15% of the ground surface, respectively. The most common of 20 species of vascular plants known from this island (Safronova and Khodachek 1989; M. Gavrilov personal observations), listed in decreasing order of importance, are *Saxifraga oppositifolia* L., *S. cespitosa* L., *Papaver radicum* Rottb., *Cochlearia groenlandica* L., *Cerastium regelii* Ostenf., *Saxifraga cernua* L., *S. hyperborea* R.Br., *S. foliolosa* R.Br., and *Cerastium bialynickii* Tolm. This island also hosts 31 species of mosses (Afonina 2015), 10 species of liverworts (Potemkin 2014),

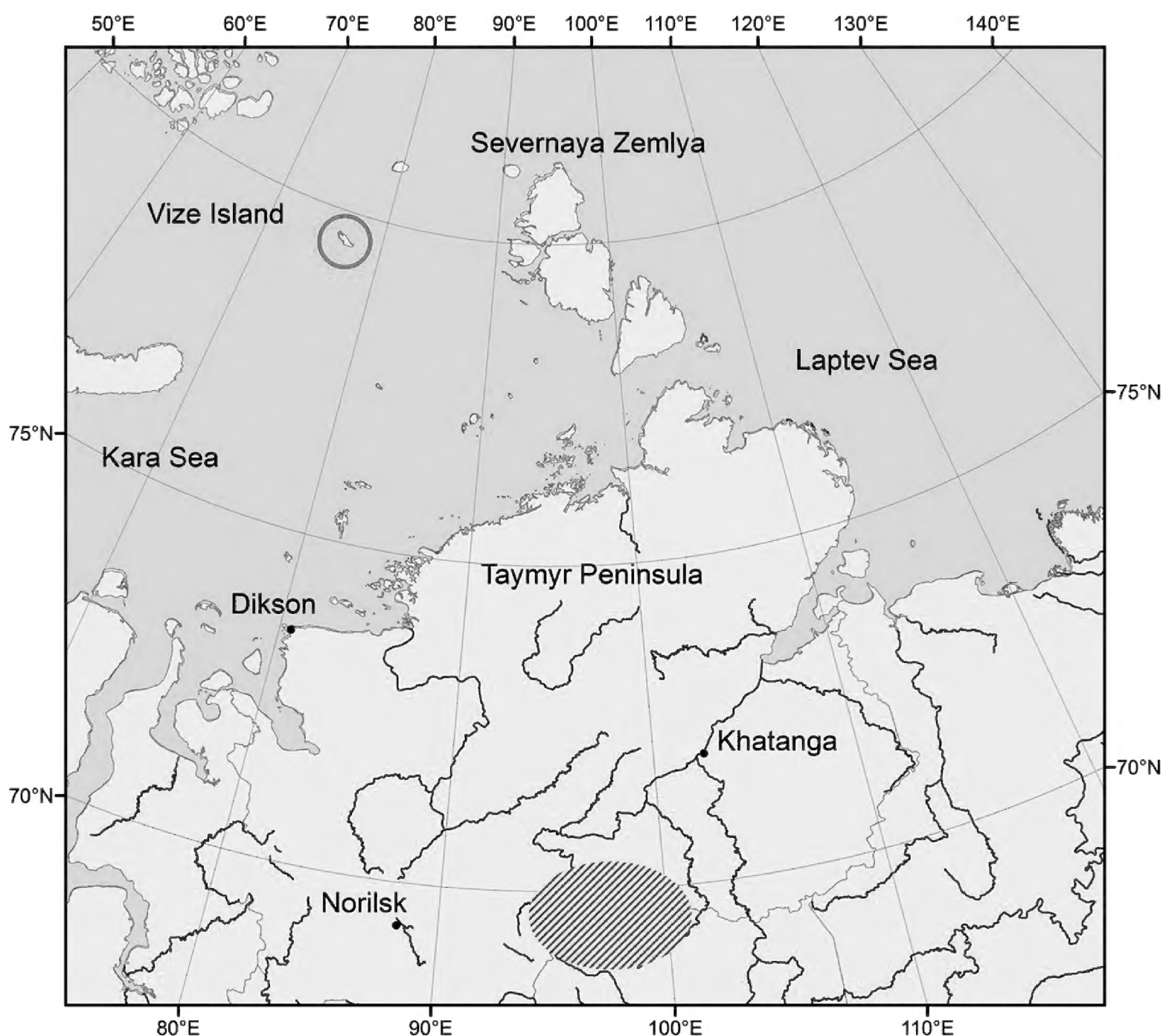
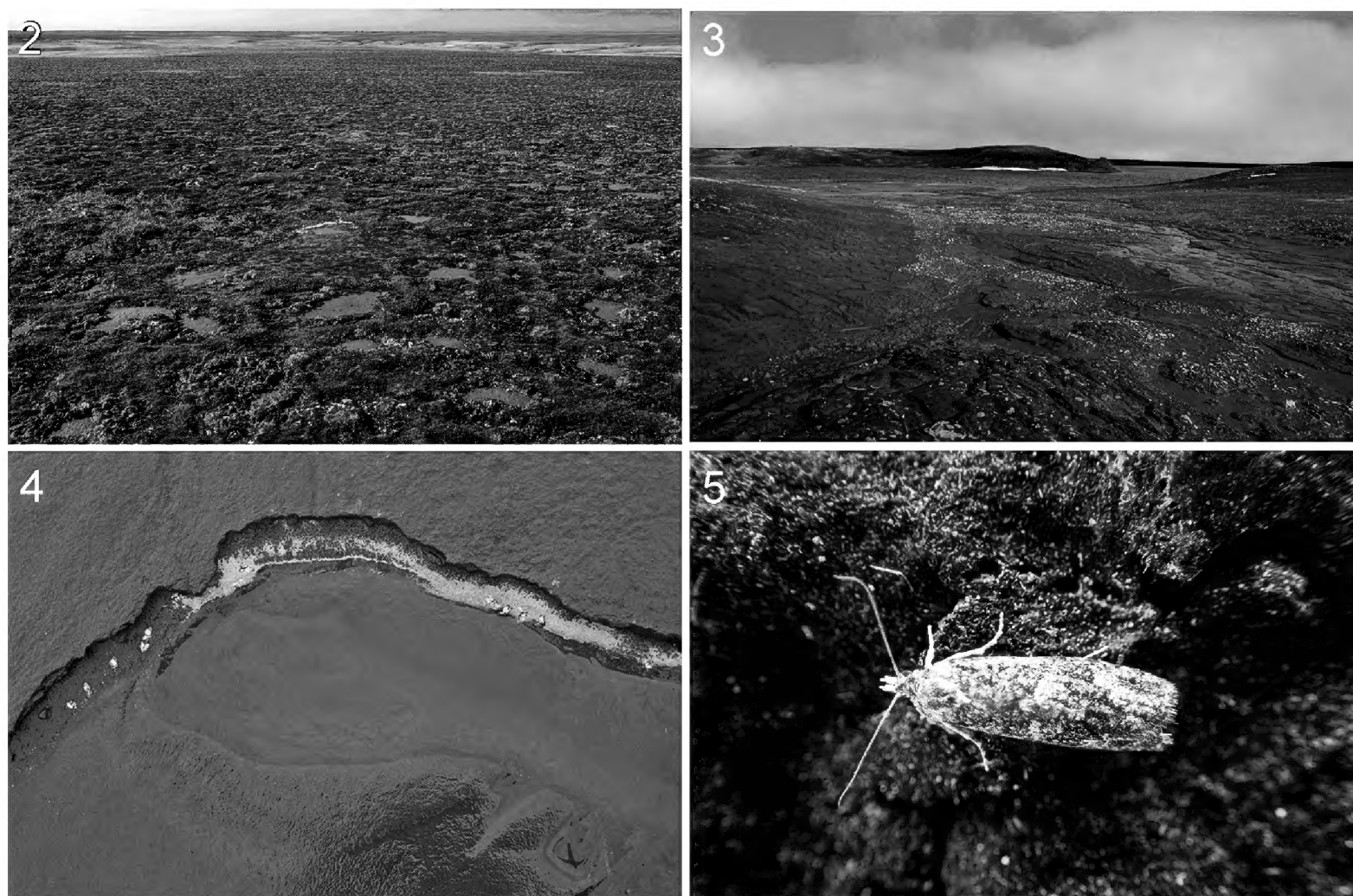


Figure 1. Location of Vize Island (red circle) and of an outbreak of *Zeiraphera griseana* (Hübner, 1799) recorded in 2020 (shaded area).



Figures 2–5. Examples of habitats on Vize Island and moths *Zeiraphera griseana* (Hübner, 1799). **2.** The typical landscape: forb and cryptogam high-Arctic tundra. **3.** Shallow river valley, at the sandy banks of which dead moths were observed. **4.** Dead moths at the stream bank. **5.** Live moth sitting on the ground.

41 species of ground lichens (Zhurbenko and Konareva 2015) and 5 species of lichenicolous fungi (Zhurbenko 2015). No terrestrial invertebrates have been recorded on Vize Island so far.

The expedition by the Arctic and Antarctic Research Institute (Russia) visited Vize Island from 9.vii.–30.viii.2020. Its aim was the exploration of Ivory Gull, *Pagophila eburnea* (Phipps, 1774) ecology, but the researchers used their stay on the island to perform the first systematic study of its biodiversity. Insects were searched by sweeping entomological nets over plants and by visual examination of flowers and moss carpets; they were also recorded during general faunistic surveys. The collected moths were preserved in paper envelopes; their identification was confirmed by examination of the male genitalia. Several specimens were relaxed, pinned and donated to the Zoological Institute (St. Petersburg) and to the Finnish Museum of Natural History (Helsinki). Weather data were downloaded from an open access web source (rp5.ru).

Results

Weather conditions

The persistent transition of daily air temperature through zero occurred on 30.vi.2020. The summer of 2020 was exceptionally warm, with mean air temperatures of 1.98 °C and 4.45 °C in July and August, respectively (Fig. 6). A moderate breeze (9–10 m/s with gusts up to 15 m/s) blowing from southeast (i.e., from the nearest continental landmass) was observed on 12–14.vii.2020 (Fig. 6). This was the only weather event of its kind during July-August, 2020.

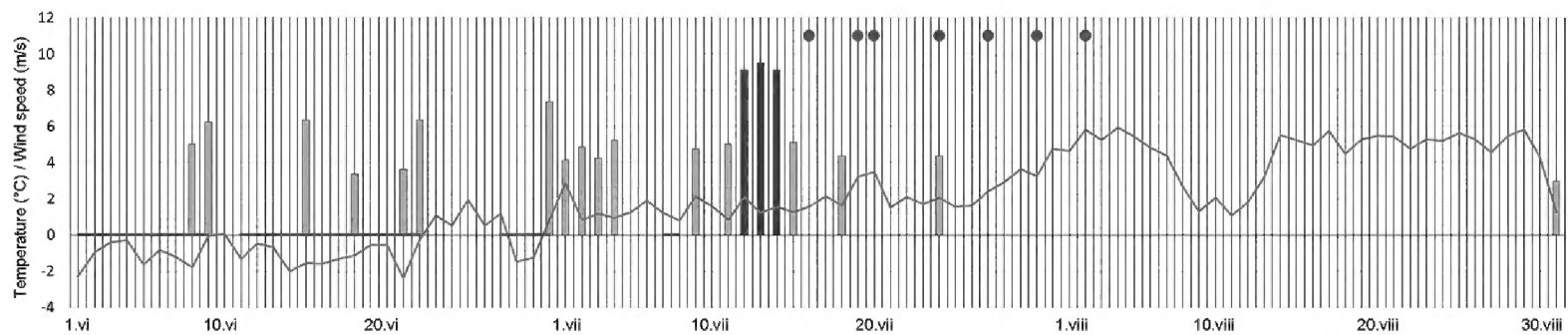


Figure 6. Weather conditions on Vize Island in summer of 2020. Red line: mean daily air temperature (°C); bars: mean daily wind speed blowing from south-east quarter (m/s; days with winds 9–10 m/s are shown by dark green bars); blue line: days with negative minimum air temperature; purple circles: days when live *Zeiraphera griseana* (Hübner, 1799) moths were observed.

Observations on moths

The live and freshly dead *Z. griseana* moths were first observed on 16.vii.2020 on the sandy banks of a pond near the meteorological station. On 19.vii, multiple freshly dead moths were discovered on sandy banks of rivers and streams along the 6 km route across the tundra north-east from the station. A total of 215 dead moths were counted within a 5×112 m area at the sandy bottom of a river valley with shallow (10–15 cm depth) streams, resulting in one moth per 2.6 m². Moths, single or in groups, were mostly found at the water's edge, along with some fine floating debris (Fig. 4). The flying moths (one at each date) were then spotted at/near the station on 20.vii, 24.vii, 27.vii and 2.viii; one moth was observed walking over the grass-lichen-moss vegetation on 30.vii (Fig. 5). Finally, multiple dead moths were seen on the sandy banks of 16 rivers or streams crossed by an 18 km route within the island on 2.viii.2020. However, no moths were seen on the same day along a 1 km part of the sandy beach at the northern coast of Vize Island. No other terrestrial invertebrates were observed or collected during this expedition, despite all reasonable efforts.

Discussion

The Larch Budmoth is widely distributed across Palearctic, reaching or approaching the northern distribution limit of coniferous forests in Finland (<http://www.laji.fi>), the Kola Peninsula in northwestern Russia (Kozlov and Jalava 1994) and the Taymyr Peninsula in Siberia (Kozlov et al. 2006). Its larvae feed on the needles of different conifers (Galkin 1992; Wermelinger et al. 2018); therefore, the migratory origin of the *Z. griseana* moths observed on Vize Island is without doubt.

Migratory behaviour is typical for *Z. griseana*, but the active migrations generally occur at the regional scale and are associated with severe defoliation of their host plant (Baltensweiler and Fischlin 1979). In Europe, periodic outbreaks of the Larch Budmoth are typical in the Alps (Baltensweiler and Fischlin 1979; Wermelinger et al. 2018), whereas outbreaks of *Z. griseana* in northern Europe are rare: we are aware of only two outbreaks in the northern part of the Arkhangelsk oblast (in 1984 and 1989; Selikhovkin 2009) and one outbreak in the Murmansk oblast of Russia (in 1980; Kozlov 1981). Both these regions are located 1200–1800 km from Svalbard, Franz Josef Land and Novaya Zemlya; nevertheless, migration of *Z. griseana* to any of the European Arctic islands has not been recorded yet (Coulson et al. 2014; Kullberg et al. 2019).

By contrast, outbreaks of *Z. griseana* in Siberia, resulting in severe damage of larch forests, have been documented since 1966 (Pleshanov and Raigorodskaya 1972), although they also likely

occurred prior to that date (Florov 1952). The northernmost outbreaks in the 1960s were reported from the Putorana Mountains (approx. 69°N; Galkin 1992) and the Nizhnaya Tunguska River (approx. 66°N; Galkin 1992). Large numbers of *Z. griseana* moths, probably originating from these regions, were observed in July of 1969 in tundra near Ust-Tareya (73°15'N, 90°36'E), some 250 km north of the northernmost larch records and some 500 km away from the continuous larch forest (Pleshanov and Raigorodskaya 1972; Chernov 1978). Even more exciting was the observation on 13–17.viii.1946 of dozens of live *Z. griseana* moths on ice in the East Siberian Sea, at a location 250–300 km from the continent and 800 km from the larch distribution limit (Andriyashev 1947; Florov 1952).

Thus, our observation of the mass occurrence of *Z. griseana* moths on Vize Island confirms that the poleward migration of this species is a sporadic but relatively frequent event. We suggest that moths were transported to this island on 12–14.vii.2020 by strong winds directed from the continent. The nearest potential source population was located in the northern part of the Krasnoyarsk region (Fig. 1), where an outbreak of this species was reported on over 75,000 ha (<http://www.xn--80aanigoucolcq3g.xn--plai/news-filials/23578.html>). Thus, the minimum travel distance of the moths was ca. 1200 km.

The dispersing insects generally require warm and dry conditions for take-off (Coulson et al. 2002). These conditions occurred near Norilsk in the Taymyr Peninsula on 13.vii, during the only day between 7.vii and 14.vii when the winds in this region blow from the south. Assuming that the wind speed along the entire route was the same as that recorded at Vize Island (i.e. 9–10 m/s), the travel time of the moths from Taymyr to Vize Island was 34–38 hours, i.e. shorter than the estimated travel time of the Diamond-back moth *Plutella xylostella* (Linnaeus, 1758) to Svalbard in 2000 (Coulson et al. 2002). Importantly, some *Z. griseana* moths remained alive and active for at least 20 days after their arrival, indicating that long-distance travel did not critically deplete resources stored in their bodies. This long activity period is somewhat surprising because, despite the exceptionally warm summer, with air temperatures exceeding the climatic norm by 2.4 °C (Anonymous 2020), the weather (Fig. 6) was still unfavourable for this boreal species.

We conclude that the high Arctic islands are less isolated from insect migrants than is commonly thought. The successful arrival of a large number of live moths from continental Siberian forests to Vize Island has once more demonstrated the absence of insurmountable physiological barriers to initial colonisation of high-Arctic islands by boreal insects.

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